Alberta
ENVIRONMENT

SOIL TESTING AND GROUNDWATER SUPPLY EVALUATION GUIDELINES FOR RESIDENTIAL SUBDIVISIONS

Prepared By:

GROUNDWATER PROTECTION BRANCH
EARTH SCIENCES DIVISION
ENVIRONMENTAL PROTECTION SERVICES

AND

LAND USE BRANCH
ENVIRONMENTAL ASSESSMENT DIVISION
ENVIRONMENTAL EVALUATION SERVICES

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TABLE OF CONTENTS

			Page
Section	1.0	General Introduction	1
	1.1	Alberta Environment as a Referral Agency	1
	1.2	The Guidelines and the Report	1
	1.3	When Do These Guidelines Apply?	2
Section	2.0	Guidelines	3
	2.1	Near Surface Water Table	3
	2.2	Soil Permeability Characterisitics	4
	2.3	Groundwater Supply	6
	2.3.1	Preliminary Groundwater Supply Evaluation	7
	2.3.2	Aquifer Testing	9
Appendix A		Near Surface Water Table Test Procedure	
Appendix B		Field Percolation Test Procedure	

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If you have any questions please contact either:

Groundwater Protection Branch
Earth Sciences Division
Environmental Protection Services
Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta T5J 3N4
Phone: 403/427-6191

Land Use Branch
Environmental Assessment Division
Environmental Evaluation Services
Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
Phone: 403/427-6196

1.0 GENERAL INTRODUCTION

1.1 ALBERTA ENVIRONMENT AS A REFERRAL AGENCY

There are a number of planning authorities which accept and render decisions on subdivision proposals. These proposals are often referred to Alberta Environment by Alberta Municipal Affairs, Regional Planning Commissions and other planning authorities. The Department is requested to comment and make recommendations on environmental concerns such as drainage, flooding, erosion, slope stability, agricultural capability and most commonly, groundwater supply and the suitability of the soil for the treatment of sewage effluent. Recognition of potential problems arising from the interaction of a proposed development with its environment assists planning authorities in delivering more informed decisions on subdivision applications.

1.2 THE GUIDELINES AND THE REPORT

Proposals for residential subdivisions are frequently sent to the Department for review. While residential subdivisions associated with major urban centres are almost always serviced with sewage collection and water distribution systems, those in smaller centres or rural areas usually are not. Where servicing is absent or partial, it is often proposed that each residential parcel have its own sewage treatment system and/or groundwater supply. In this case, it is the Department's philosophy that each proposed residential parcel should have adequate natural area for development of a residence, suitable soils for treatment of sewage effluent, and a sufficient supply of potable groundwater protected over the long-term from contamination.

To achieve the above objectives, these guidelines set forth accepted standards of investigation to evaluate the near surface water table, determine soil permeability characteristics, and establish the potential groundwater supply for the proposed subdivision.

The results of these investigations should be submitted in report form to the appropriate planning authority and the Regional Land

Use Branch. Three copies of the report should be submitted to the latter.

1.3 WHEN DO THESE GUIDELINES APPLY?

These Guidelines are to be utilized for unserviced or partially serviced residential subdivisions where:

1) Six or more parcels are proposed per quarter section; or

2) Whenever in the Department's judgement there is the potential for contamination of surface water or groundwater by sewage effluent and/or the distinct possibility of insufficient groundwater supply.

2.0 GUIDELINES

2.1 NEAR SURFACE WATER TABLE

Near surface groundwater is observed as standing water in the bottom of a shallow observation well. The surface of this standing water corresponds to the near surface water table. The level of this water table can fluctuate during the year at any location. In addition, at any given time, water table levels may vary considerably over short distances.

Our Department defines a high water table area as any area where the water table is generally within 2.1 metres (7 feet) of the ground surface. Seasonal or permanently high water table levels can:

(1) Adversely affect the functioning of a sewage treatment system, which could lead to shallow groundwater and/or surface water contamination;

(2) Render the area unsuitable for normal residential development.

One of the basic methods for determining water table levels is the near surface water table test. The test consists of drilling a hole (shallow observation well) to a depth of 3.0 metres (10 feet), allowing the water level to stabilize, then measuring the distance from the ground surface to the water level. A detailed test procedure is included in Appendix A.

In order to be meaningful, the specific results of a water table test hole program should be evaluated with respect to other attributes of the site gathered by site inspection, examination of aerial photographs, and if necessary, investigation of area records. A number of factors such as weather, surficial stratigraphy, topography and flooding affect the water table level at any given place and time. Vegetation type and soil development tend to reflect the interplay of these factors and the resultant long-term range of water table levels.

Using the above criteria, if the water table is determined to be within 2.1 metres of the ground surface anywhere within the site, then these high water table areas should be delineated on a topographic map. This map also should outline major vegetation types and show the location of all water table and percolation test holes. In addition, the stablized water table level within each water table test hole should be included.

If bedrock is determined to be within 2.1 metres of the ground surface, it should be delineated on the topographic map and its lithology described.

2.2 SOIL PERMEABILITY CHARACTERISTICS

Soil can be an effective treatment medium for sewage tank effluent (wastewater) through the following natural processes:

1) Filtration - removal of suspended solids as they pass through the soil;
2) Biological Degradation - aerobic (air-breathing) microorganisms whose natural habitat is the surface and upper layers of the soil, consume the organic materials (suspended solids, intestinal and disease causing bacteria) within the wastewater and break them down into simple and stable compounds.
3) Adsorption - dissolved chemical constituents cling to soil particles and become available to plants.

The rate at which wastewater can pass through soil is a function of soil permeability. Permeability is greatly affected by the size of grains as well as their shape, packing and uniformity of size. Generally, sands and gravels are considered very permeable, while clay, which is fine grained, is only slightly permeable (nearly impermeable).

Soils which have moderate permeability and low water table conditions are ideal for the treatment of sewage effluent. On the other hand, soils which are nearly impermeable have a definite tendency to

become saturated with wastewater. In this case, aerobic microorganisms are eliminated because oxygen is no longer available. As a consequence, the breakdown of wastewater is greatly reduced and a danger to health may occur. As well, the suspended solids accumulate rapidly within the soil pores, thus further reducing the soil permeability. The end result is that the entire sewage treatment system becomes inoperative. In very permeable soils, problems arise because there is inadequate contact time between the wastewater and soils for treatment by biological degradation and adsorption. This may result in the contamination of shallow groundwater by only partially treated wastewater.

There are several methods available whereby the applicant or his representatives can evaluate the soil permeability.

1) Percolation Test - The standard percolation test should be done, except when frost conditions exist in the ground. This test requires that an additional hole be drilled in the vicinity of each water table test hole (refer to attached test procedure - Appendix B). The following table summarizes our Department's position on percolation rates as they relate to the suitability of soil for sewage treatment by subsurface systems.

Percolation Rate			Inferred Soil Permeability	Suitability of Soil for Sewage Treatment
minutes/cm	minutes/inch	defined as		
less than 2.0	less than 5	fast	very permeable	unfavourable
2.0 to 23.6	5 to 60	moderate	moderately permeable	favourable
more than 23.6	more than 60	slow	slightly permeable	unfavourable

2) Grain Size Analysis - When frost conditions exist, a grain size analysis of material obtained at a depth of between 60 to 75 centimetres (24 to 30 inches) below the ground surface may be undertaken. Material for this test also can be acquired from the water table test hole at the time of drilling.

A qualified soils consultant should supervise the drilling and collection of these soil samples. All samples are to be analyzed by a soils testing laboratory, using standard test procedures to determine the percentage by weight of gravel, sand, silt and clay in the soil sample. Possible test procedures include the Modified Hydrometer Method or a combination of sieve and hydrometer analyses.

3) Alternate Methods - A consultant qualified in the area of soils and sewage treatment may be retained to determine the suitability of the soil for on-site sewage treatment. It would be up to the consultant to determine the types of tests and procedures which would enable him to say the subdivision is suitable or not suitable for development.

2.3 GROUNDWATER SUPPLY

It is our philosophy that each parcel within a proposed residential subdivision should have a sufficient long-term supply of potable groundwater. This section of the Guidelines sets forth accepted standards for the evaluation of the groundwater supply. It should be utilized when six or more parcels are proposed per quarter section, or whenever in our opinion there is a distinct possibility of insufficient groundwater supply.

The technical evaluation of the potential groundwater supply should be prepared by a recognized professional consultant (or by an individual otherwise qualified in the groundwater field). This evaluation usually consists of two parts:

1) A Preliminary Groundwater Supply Evaluation involving the collection, summary and interpretation of existing groundwater data; and

2) Aquifer Testing utilizing a new or existing well within the proposed subdivision, which is necessary if the Preliminary Groundwater Supply Evaluation does not provide adequate information for the determination of the groundwater supply potential.

2.3.1 PRELIMINARY GROUNDWATER SUPPLY EVALUATION

The Preliminary Groundwater Supply Evaluation consists of the collection, summary and interpretation of existing groundwater data. This evaluation serves several important purposes.

1) It provides an estimate of the potential groundwater supply for the proposed subdivision.
2) The estimate coupled with an assessment of the comprehensiveness of the existing groundwater data assists in the determination of whether aquifer testing is necessary.
3) If aquifer testing is recommended, knowledge of the local hydrogeological setting can help identify site specific requirements.

COLLECTION OF EXISTING GROUNDWATER DATA

Groundwater Information Services maintains a provincial groundwater data archive of Water Well Driller's Reports, aquifer tests, chemical analyses, electric logs, etc. All groundwater data pertaining to the proposed subdivision and vicinity (within a minimum of 3.2 kilometres or 2 miles) should be obtained by the consultant at the following address.

GROUNDWATER INFORMATION SERVICES
HYDROGEOLOGY BRANCH, EARTH SCIENCES DIVISION,
ALBERTA ENVIRONMENT
#404, ENERGY SQUARE
10109 - 106 ST.
EDMONTON, ALBERTA
PHONE: 403/427-2770

SUMMARY OF COLLECTED GROUNDWATER DATA

Collected groundwater data should be summarized through a combination of text, tables, maps and drawings. The summary should include the following information for the evaluation area (within a minimum of 3.2 kilometres of the proposed subdivision).

1) A map showing all well locations within the evaluation area;
2) Ground elevation (actual or estimated) of all wells;
3) Well construction details;
4) Lithologic logs, well depths and static water levels;
5) Depth, thickness and lithology of water-bearing zones;
6) Aquifer coefficients (transmissivity, theoretical 20 year yield, apparent yield) based on existing well information;
7) Chemical analyses of well water; and
8) Cross-sections depicting an interpretation of subsurface geology.

INTERPRETATION AND EVALUATION

The consultant should interpret the collected data and summary, and evaluate the potential groundwater supply for the proposed subdivision.

OUR RECOMMENDATION

On the basis of the Preliminary Groundwater Supply Evaluation, one of three recommendations will be forwarded to the appropriate planning authority advising that:

1) Sufficient groundwater supply (quantity and quality) is available to meet the household requirements of the proposed subdivision. The household requirements are calculated assuming one well will supply the proposed and existing lots within an area of 64.7 hectares (160 acres). The requirements are currently calculated assuming water

consumption is an average of 1091 litres/day/lot (240 imperial gallons/day/lot). These requirements include an amount necessary for human consumption and sanitary purposes, but does not provide for fire protection, irrigation, livestock, or any other outdoor requirement;

2) Sufficient groundwater supply is not available to meet the domestic requirements of the proposal; or

3) The preliminary report does not contain sufficient information to determine the groundwater supply potential of the area.

2.3.2 AQUIFER TESTING

If the Preliminary Groundwater Supply Evaluation is considered insufficient to properly evaluate the groundwater potential of an area, we will recommend aquifer testing. Should the appropriate planning authority deem this necessary three copies of the Aquifer Testing Report should be submitted to the Regional Land Use Branch.

Two options are available to the developer if an aquifer test is required:

1) An existing well on the property may be tested; or
2) A new well may be drilled and tested.

An existing well may be tested only if the consultant has sufficient information available to properly interpret the aquifer test results. Such information must include a lithologic log, depth of production zone(s), and all well construction details.

If an existing well cannot be tested due to physical limitations, or insufficient information then a new well within the proposed subdivison should be drilled, fully developed and tested. The well should be placed either near the centre of the property or, in special cases, at a position selected by Alberta Environment staff.

Depending upon the nature of the aquifer from which the water supply is to be obtained, and the density of the proposed development, more than one well (and aquifer test) may be required. For example, if surficial sand and/or gravel aquifers are to be utilized, and their extent is in doubt, additional wells and/or test holes may be recommended.

INFORMATION REQUIRED OF AN AQUIFER TEST ON NEW OR EXISTING WELLS

The results of all aquifer tests should be submitted with the Aquifer Testing Report and should contain the following information:

1) Detailed lithologic log (and electric log if available) of the tested well(s);

2) Length of aquifer tests, pumping rate, method of flow control, and depth of pump intake;

3) Table of drawdown and recovery measurements taken during pump tests, and method of water level measurement;

4) Graph of drawdown and recovery measurements versus time (in minutes) plotted on semi-logarithmic paper;

5) Calculated transmissivity and theoretical 20-year yield based on an interpretation of aquifer test results;

6) Well construction details including the ground elevation (actual or estimated) of the well head and a map accurately showing its location; and

7) Chemical analysis of well water sampled during the aquifer test.

The following paragraphs contain details which will serve to clarify the type of information required of aquifer tests conducted on new and existing wells. Methods of obtaining information are necessarily flexible as field conditions should dictate the approach to aquifer evaluation.

1) DETAILED LITHOLOGIC LOGS - Detailed lithologic logs are essential in order to delineate potential water-bearing zones, and to correlate the subsurface geology between adjacent wells. A detailed lithologic log should therefore note variations with depth in lithology, texture, hardness, colour, moisture, plasticity, drilling rate, stability of the unsupported bore wall, and any other noteworthy physical characteristics of the material being penetrated. Due to the inherent difficulty in obtaining pure samples from deeper levels with most types of drilling equipment, electric logs (resistivity, spontaneous potential and gamma) are invaluable aids in distinguishing the precise depth of some lithologic variations. They are also useful in determining aquifer intervals.

2) LENGTH OF AQUIFER TESTS AND PUMPING RATE - The total length of time that aquifer tests are conducted (drawdown and recovery) depends to a large degree on subsurface geology, aquifer characteristics, and boundary conditions which limit the amount of water available to the well. As a consequence, the duration and pumping rate of an aquifer test should be determined in the field by the consultant. In all cases the test should consist of a <u>minimum 12 hours pumping and 12 hours recovery</u>.

Longer tests are advised when one or more of the following is present:

a) the proposed lot density is great;

b) barrier boundaries or fracture permeability are suspected in the area; or

c) the water level drops substantially in the last few hours of an aquifer test (in this case, the test should be continued until the trend is firmly established).

The pumping rate at which the test is conducted should be as great or greater than the theoretical 20-year yield which is required to supply the proposed subdivision. Calculated theoretical 20-year yields which are significantly greater than the pumping rate maintained during the aquifer test are considered unreliable.

There are a number of natural factors which can cause deflections in the time-drawdown curve such as boundary effects, dewatering in water table cases and continual development in the well. As it can be difficult to separate these effects from one another, it is crucial that the pumping rate variation be reduced to less than 5% by constant monitoring and adjustment. The actual pumping rate (or pressure readings on a flow restrictor) should be documented every 10 minutes for the first hour of pumping. After one hour, readings should be taken at the time of drawdown measurements. The level at which the pump is set within the well should also be documented.

3) WATER LEVEL MEASUREMENTS - Water level measurements during pumping and recovery intervals of the aquifer test should be recorded at precise intervals to the nearest 0.5 cm (0.2 inch) in order to properly evaluate aquifer test results. A time schedule similar to the following should be used for taking drawdown and recovery measurements.

1 to 10 minutes	every minute
10 to 30 minutes	every 5 minutes
30 to 60 minutes	every 10 minutes
1 to 2 hours	every 15 minutes
2 to 4 hours	every 30 minutes
4 to 12 hours	every hour
12 to 24 hours	every 2 hours
24 to 36 hours	every 4 hours
36 to 48 hours	every 6 hours
after 48 hours	every 8 to 12 hours

4) INTERPRETATION OF RESULTS - The Jacob Method of aquifer evaluation is the most widely used method in Alberta for determining the long-term theoretical yield from domestic wells serving single family dwellings. The method should be useful in the majority of cases for determining aquifer properties from test results.

The Jacob Method simplifies the calculation of aquifer coefficients by reducing the relationship between transmissivity (T), pump rate (Q), and drawdown(s) to the following:

$$T = \frac{2.30\ Q}{4\pi \Delta s} \quad \text{or} \quad T = \frac{264\ Q}{\Delta s}$$

T is the transmissivity, in $m^3/day/m$ (m^2/day)	or	T in igpd/ft
Q is the constant rate of pumping, in m^3/day	or	Q in igpm
Δs is the drawdown, in m/log cycle time interval	or	Δs in ft/log cycle time interval

where Δs is the change in water level per cycle for the straight-line portion of the drawdown versus time graph, and Q is constant pump rate during the test. The theoretical 20-year yield (Q_{20}) of the well is then determined by:

$$Q_{20} = 0.68\ (T)(H)(0.7) \quad \text{or} \quad Q_{20} = \frac{(T)x(H)}{2110}\ (0.7)$$

$Q_{20} = m^3/day$	$Q_{20} = igpm$
$T = m^3/day/m$ (m^2/day)	T = igpd/ft
H = meters	H = feet

where T is transmissivity and H is available head. For confined aquifers, H is the distance between the top of the main aquifer, and the static or pre-pumping level of water in the well. For unconfined aquifers, H is arbitrarily chosen as 2/3 of the elevation difference between the base of the aquifer and the static water level. An arbitrary factor of 0.7 is included into the 20-year yield determination.

The safety factor is used to offset overestimates of sustained yield which result from assuming the aquifer to be of infinite extent, of constant thickness, homogenous and isotropic.

Another variation of the 20-year yield calculation is commonly used in the Department where extreme well losses are encountered:

$$Q_{20} = \frac{(Q) \quad (H)}{s_{10} + 6\Delta s}$$

In this instance, Q, H, and Δs are as previously defined and s_{10} is the drawdown at 10 minutes. These variables can be expressed in either Metric or English units provided the units are consistent.

The formulas presented in these guidelines are the most commonly used for evaluating aquifer coefficients of single family wells. This is not to suggest, however, that alternative methods of evaluation would not be acceptable or should not be employed under special circumstances. Retesting or reevaluation at a later date could also be recommended.

5) WELL CONSTRUCTION DETAILS - Details of the construction of all pump tested wells are required. This includes the length and diameter of all casing, liners, seals, and descriptions of all fittings, pumps, screens, filter packs, et cetera, used in constructing the well. In addition, details of the method and the length of time the well was developed should be included.

6) CHEMICAL ANALYSIS - During an aquifer test, a water sample should be taken for chemical analysis. Samples should be taken in a clean container of about one litre size and should be analyzed as soon as practical after sampling at one of the commercial laboratories in the Province. Samples should not be allowed to freeze or be subjected to excessively high temperatures or sunlight. Samples containing sediment (suspended or settled) should be filtered immediately upon withdrawal from the well. All water samples must be analyzed for the following constituents:

1) pH;
2) Ca and Mg separately;
3) Total dissolved solids;
4) Na + K (may be calculated);
5) CO_3 and HCO_3 separately;

6) SO_4;

7) Cl;

8) NO_3;

9) Fe;

10) F;

11) Hardness and alkalinity, as $CaCO_3$; and

12) Electrical Conductivity.

All constituents are to be reported in mg/L. Parameters such as pH and electrical conductivity should carry appropriate standard units.

Bacteriological analyses are not required on a routine basis, however, samples should be obtained from any new or existing wells within the proposed subdivision if it is suspected that an underlying aquifer has been contaminated. Sample bottles may be obtained and returned to your local Provincial Health Unit.

If non-bacteriological contamination is suspected then additional appropriate chemical analyses should be undertaken.

APPENDIX A

NEAR SURFACE WATER TABLE TEST PROCEDURE

WATER TABLE TEST HOLES

a) Number: As a general rule there should be 10 water table test holes per quarter section. The consultant may increase this number if necessary for the proper delineation of high water table areas. The location of each test hole should be indicated on a topographic map of the proposed subdivision (refer to section 2.1 for details of mapping requirements).

b) Hole Depth: Auger (drill) by hand or otherwise a hole to a minimum depth of 3.0 metres (10 feet). In sandy soils where contamination of the water table is of concern, deeper test holes are recommended.

c) Soil Log: A description of the soil types (lithology) found in each hole, as determined in the field by a soils consultant shall be submitted. For example:

Water Table Test Hole 1

0 to 4 cm - sandy loam, dark brown

4 to 45 cm - sand, medium to dark brown, slightly moist, fine-grained

45 to 300 cm - silty clay, dark olive brown, slightly moist to moist, slightly plastic

d) Water Level Measurement: Allow the water level to stabilize in the hole and measure the distance from the ground surface to the water level. This stabilization period will be a minimum of 24 hours in sandy soils and 96 hours in clayey soils. Include in the report the time allowed for stabilization and the date of testing.

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APPENDIX B

FIELD PERCOLATION TEST PROCEDURE

1. THE PERCOLATION TEST HOLE

a) Location: The hole should be a minimum of 3.0 metres (10 feet) from any other hole (natural or man-made). The location of the hole should be indicated on a topographic map of the proposed subdivision (refer to section 2.1 for details of mapping requirements).

b) Hole Size: Auger (drill) by hand or otherwise, a 15 to 20 centimetre (6 to 8 inch) diameter hole, to a depth of 90 centimetres (35 inches).

c) Soil Log: A description of the soil types in each hole should be submitted. For example:

Percolation Test Hole 1
0 to 10 cm. - clay loam
10 to 70 cm. - clay
70 to 90 cm. - coarse sand

d) Hole Preparation: Carefully scratch the bottom and sides of the hole with a sharp pointed instrument in order to provide a natural soil interface into which the water may percolate. Remove all loose material from the hole.

2. INITIAL SOAKING PERIOD FOR CLAYEY AND SANDY SOILS

Gently pour clear water into the percolation test hole until the water level is 45 centimetres (18 inches) below the ground surface (refer to PERCOLATION TEST HOLE DIAGRAM).

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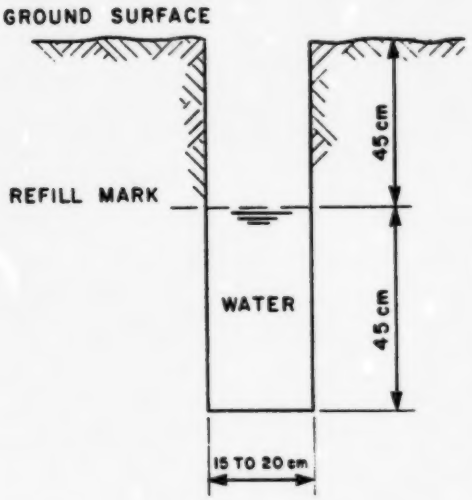
THE PERCOLATION TEST HOLE DIAGRAM



a) Clayey Soils - If the soil has a clayey texture and it takes more than 10 minutes for the water to seep completely away, the 45 centimetre level should be maintained for at least 4 hours or preferably overnight. This procedure is to insure that the soil is given ample opportunity to swell. Percolation tests carried out under these conditions will be comparable to those conducted during wet periods and will provide valuable information on the percolation characteristics of the soil under normal septic field conditions.

b) Sandy Soils - If the soil has a sandy texture and it takes less than 10 minutes for the water to seep completely away, the percolation test may proceed immediately without the minimum 4 hour soaking period. This is because swelling should be minimal in this type of soil.

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EVALUATION GUIDELINES FOR RESIDENTIAL SUBDIVISIONS"

3. TWO ALTERNATIVE PERCOLATION RATE TESTS

Two methods are available for determining the percolation rates. Regardless of which method is used, the values of all measurements made on each percolation test hole should be submitted with the report.

Fixed Time Interval and Refill Method

Add water to the percolation test hole until the 45 centimetre REFILL MARK is reached. Measure and record the drop in water level after an interval of at least 10 minutes. From this measurement the rate of drop of water in minutes per centimetre or minutes per inch can be calculated. For example:

Test Hole 1 $\frac{\text{10 minutes}}{\text{2 centimetres}}$ = 5 minutes per centimetre of drop

Repeat the above procedure a number of times until the percolation rates of three consecutive measurements are relatively the same (the three values vary by less than 10%). It should be noted that water must be added to the REFILL MARK everytime a test is conducted on the percolation test hole.

Variable Time Interval Non-Refill Method

This test begins with the addition of water to the percolation test hole until the 45 centimetre REFILL MARK is reached. The water level is then allowed to decline without interference. Record on at least 4 occasions the declining water level and the time since the beginning of the test. The water should be observed over a minimum of 2 hours or a drop of at least 15 centimetres (6 inches). For each increment of drop (example 2 centimetres) and associated time increment (example 16 minutes) calculate the rate of drop of water in minutes per centimetre or minutes per inch. For example:

Test Hole 2 $\frac{\text{16 minutes}}{\text{2 centimetres}}$ = 8 minutes per centimetre of drop